

set them vibrating in unison with the original vibrations of the radiating source. If it were not that the receiving body were subjected to external influences, it would acquire little by little exactly the same temperature as the body from which the radiations were emitted. In other words thermic equilibrium would be established between the two, quite irrespective of the distance between them. We know that the rays of the sun traverse space without any diminution in their frequency or wave-length. It follows, therefore, that the sun's rays are able to raise to a temperature equal to that of the sun's surface any body on the surface of the earth on which they can be concentrated, provided only such a body could be preserved from losing heat by conduction or radiation. Although a certain quantity of the solar radiation is arrested by absorption in the imperfectly transparent atmosphere surrounding the earth, measurements made at places so widely apart as Cairo, Paris, and St. Petersburg agree in showing almost identical values for the amount of heat received from the sun, and which is about twelve calories, per square metre, per minute.

Now on the supposition that all the metalloids, with the exception, perhaps, of oxygen, are dissociated in the sun, thermal equilibrium, if thus experimentally obtained, ought to affect the dissociation of them upon our globe also.

M. Pictet therefore proposes that an enormous parabolic mirror should be constructed, in the focus of which the sun's rays should be concentrated upon the various metalloids which it is sought to decompose. All the data for calculating the requisite size of the mirror are known to a certain approximative value, with one exception. We know the quantitative intensity of solar radiation, and the reflecting power of polished metals, and hence can calculate how many units of heat a mirror of given size will hurl into its focus per minute. *We do not know* how much heat must be furnished to a given weight of any one of the hitherto undecomposed metalloids to dissociate it, but we are quite certain that this quantity must be much greater than that produced by the combustion of an equal weight of hydrogen and oxygen. Assuming that to dissociate bromine required *a hundred times* as much heat (at the temperature of its dissociation-point) as water vapour requires (at its dissociation-point) to split it up, M. Pictet calculates that a single gramme of bromine must have 350 calories expended upon it to resolve it into its elements. Further calculation leads him to consider that to dissociate one gramme of bromine per minute, would require that the solar rays should be concentrated by a mirror of *at least 35 sq. metres* of surface, measured normally to the rays, or of about ten metres' aperture. It would, he thinks, be best constructed in separate pieces of about a square metre in area, each ground and polished to a true curve and mounted in a special frame. The depth of the mirror should be equal to half its aperture, bringing the focus into the plane of the rim. At the focus would be a special *solar chamber*, or crucible, constructed of lime or zircon, or other refractory substance, into which the vapours to be operated upon would be led. To avoid loss of heat it would be kept hot from without by oxyhydrogen flames. The whole apparatus ought not, he thinks, to weigh as much as two tons. To catch and retain the dissociated substances, and to prevent their immediate recombination, he proposes to aspirate the vapours of the chamber through metal tubes containing metallic gauze, and cooled from without to a temperature perhaps as low as  $-50^{\circ}$  by intense artificial refrigeration. The rapid cooling thus produced should hinder at least a considerable proportion of the constituents from recombining as fast as they were liberated from each other in the solar chamber.

There is much that is suggestive in the proposals of M. Pictet; so much, indeed, that any attempt at criticism or comment would outrun the limits of this article, which is

therefore simply devoted to the exposition of M. Pictet's ideas in phrases as nearly identical as possible with those in which he has himself expressed them.

S. P. T.

#### THE DESTRUCTION OF INSECT PESTS, AN UNFORESEEN APPLICATION OF THE RESULTS OF BIOLOGICAL INVESTIGATION

"WHAT is the good of a knowledge of microscopic creatures? What is the good of prying into the anatomy of insects? It is all very well as an amusement, but serious persons can not be expected to assent to the devotion of endowments or state-funds to such trivial purposes. Chemistry, geology, electricity, if you please, have their solid commercial value, but biology is an amusement for children and old gentlemen." Such is the opinion of many a "practical man," ignorant and shortsighted as the genus invariably proves itself.

Already the practical man may be told in reply, that surgery is entirely reformed by our knowledge of the minuter fungi, that by avoiding the access of Bacteria to wounds, we avoid a large destruction of human life; already we see our way to avoiding some deadly diseases caused by these same Bacteria now that we know them to be the active cause of such disease. Already silk is cheaper in consequence of our knowledge of the Bacteria of the silk-worm disease; already better beer is brewed and better yeast supplied to the baker in consequence of Pasteur's discovery of the bacterian diseases of the yeast-plant; already vinegar-making, cheese-making, butter-making, wine-making, and other such manufacturing trades are on the way to benefit by like knowledge. Potato-disease and coffee-disease have been traced to their causes and means suggested by biologists for dealing with the parasitic plants causing those diseases, whereby not thousands but millions of pounds sterling a year may be saved to the community.

Insect pests which have depopulated whole provinces, such pests as the Phylloxera and the Colorado beetle, are about to receive a check at the hands of the same class of scientific students. The application of knowledge of natural facts is in this case a very remarkable one; for it is actually proposed to make use of our recently acquired knowledge of diseases due to Bacteria—not that we may arrest such diseases, but that we may promote them. Insect pests are to be destroyed by poisoning them not with acrid mineral poisons which damage plants as well as the insects, but by encouraging the spread of the disease-producing Bacteria which are known to be fatal to such insects. Prof. Hagen, of Cambridge, Mass., has called attention to the old practice of destroying greenhouse pests by the application of yeast. He conceives that this method may be applied to other insect-pests, such as Phylloxera, Colorado beetle, cotton worm, &c. He imagines that the yeast-fungus enters the body of the insect on which it is sprinkled and there produces a growth which is fatal to the insect's life. It is a well-known fact that insects are very subject to fungoid diseases and it is also ascertained that the application of yeast to the plants frequented by such insects favours their acquisition of such disease. Prof. Elias Metschnikoff, the celebrated embryologist, has however made some investigations on this subject and given an explanation of the possible value of yeast application (*Zool. Anzeiger*, No. 47), different and more satisfactory than that which Prof. Hagen appears to adopt.

The general result of the most accurate investigations of the beer-yeast fungus (*Saccharomyces cerevisiae*), is entirely opposed to the notion that it can enter an insect's body and produce a disease. Beer-yeast is beer-yeast and appears always (or within experimental limits) to remain so. On the other hand De Bary has made known the life history of some simple fungi which destroy insects,

and from Pasteur, Cohn, and others we know of diseases due to those simplest of fungi, the Bacteria, which produce the most deadly ravages amongst insects. Prof. Metschnikoff has examined some of these minute parasitic fungi and cultivated them by passing them from one insect to another, and has experimentally proved their very deadly character to the insects exposed to infection. The "green Muscardine" (*Isaria destructor*) is the name given by Metschnikoff to one of the minute fungi the effects of which he most successfully traced. Now it is perfectly evident that if green Muscardine spores could be produced in large quantity, or spores of similar disease-producing fungi, and applied to the ground and shrubs infested by insect-pests liable to harbour those fungi, we should have the best of all means for effecting the destruction of the insects, viz., a poison which once set at work would spontaneously multiply and spread its destroying agents around.

Accordingly Prof. Metschnikoff endeavoured to cultivate the "green Muscardine" apart from insects, so as to obtain its spores if possible in great quantity, in a liquid which might be applied to places attacked by injurious insects. He at last succeeded in effecting this cultivation by the use of beer-mash in this decoction the green Muscardine produced a rich mycelium and finally spores.

It is exceedingly probable that we have here the true explanation of the value of the application of yeast to plants, &c., affected by insect pests. If there are a few spores only of such parasites as the "green Muscardine," about, the fluids of the yeast will serve them for nourishment and so cause the Muscardine to spread until it comes into contact with the insects. There is no reason to suppose that the beer-yeast plant itself is capable of generating a disease in any insects, at the same time we must remember that yeast as ordinarily used by the brewer is by no means pure; it contains in small quantities other minute fungi besides the *Saccharomyces cerevisiae*, and it is quite possible that a given quantity of it, say a pint, may, if the brewery from which it came were not conducted on the most perfect system (such as that lately introduced by Pasteur), contain a few spores of such a disease-producing parasite as Muscardine. A diseased insect once in a way falling into the mash-tub would sufficiently keep up the supply, and thus it is possible that yeast may carry infection to insect-pests and destroy them.

At the same time Prof. Metschnikoff's suggestion of a deliberate cultivation of an insect's-disease-producing fungus, and the application of the cultivated fungus in quantity to places infested by these insects, is in the highest degree ingenious and likely to give results the value of which will be estimated in thousands of pounds, and so do something to persuade "practical" men that all science is deserving of their respect and encouragement.

E. RAY LANESTER

#### THE CLASSIFICATION OF THE ENGLISH TERTIARIES

AT the last meeting of the Geological Society of London an animated discussion took place upon the question of the true correlation of the strata of the Hampshire Basin with those of France, the Netherlands, North Germany, Switzerland, and other parts of Europe. This discussion was raised by a memoir read by Prof. Judd, who showed that the accepted order of succession in the series of fluvio-marine strata of the Isle of Wight is not the true one, but that the formation in question is of much greater thickness and importance than had hitherto been supposed by geologists.

These fluvio-marine strata of the Hampshire Basin, which, as is well known, are quite unrepresented in the London area, have attracted much attention from British and foreign geologists. The order of their succession has

been the subject of frequent controversies in the past, for, like all deposits formed in deltas, the beds are inconstant in character and thickness, and it is difficult to trace them at the surface by the art of the geological surveyor; furthermore, the districts of the New Forest and the northern half of the Isle of Wight, in which the strata in question are found, are covered with thick deposits of sand and gravel, so that the underlying strata are seldom exposed except in sea cliffs and in such artificial openings as railway-cuttings, brickyards, quarries, and wells.

The first classification which was proposed for these beds was the result of the long and careful study of the geology of the Isle of Wight by Thomas Webster. He believed that the fluvio-marine beds consist of a set of marine strata with fresh-water deposits above and below them. But the more careful study of the palaeontology of the formation by Prestwich and Edward Forbes proved that Webster had confounded in his "marine series" several strata which are on very distinct geological horizons. In the memoir now laid before the Geological Society Prof. Judd carries the question one step further in the same direction, and demonstrates that strata exposed at Colwell Bay and at the base of Headon Hill are not, as was hitherto supposed, upon the same horizon, but that the latter underlie the former. The classification now proposed for these fluvio-marine strata, which are shown to have a thickness of from 800 to 900 feet, is as follows:—

Hempstead series (marine and estuarine) ...	100 feet.
Bembbridge group (freshwater and estuarine)	300 "
Brockenhurst series (marine) ... ... ...	25 to 100 "
Headon group (freshwater and estuarine), including the Headon Hill sands ... ...	400 "

The Headon group is proved to be the exact representative of the *Zone of Cerithium concavum* which has been recognised at so many points upon the Continent.

Edward Forbes's division of the "Osborne and St. Helen's Series" it is shown must be abandoned, on the ground that it presents no good features, either mineralogical or palaeontological, by which it can be distinguished, and its separation was founded on an error in working out the true order of succession of the beds. On the other hand, the marine strata seen about Lyndhurst and Brockenhurst in the New Forest, and at Colwell Bay and Whitecliff Bay in the Isle of Wight, are shown to constitute a division of very great importance for which the name of the *Brockenhurst Series* is proposed.

Since the date of Edward Forbes's study of these beds, much new light has been thrown upon their age and relations by the collection and study of the fossils which they contain; the number of species now known to us is probably, at least four times as great as those with which Forbes was acquainted, this result being mainly due to the labours of the late Mr. Frederick Edwards and other indefatigable collectors of tertiary fossils.

It is greatly to be desired that the rich stores of molluscan, reptilian, and mammalian fossils, which exist in the British and other museums, should be described by competent naturalists, as much new light would thereby be thrown on the life of the period when these beds were deposited.

Great difficulty has always been experienced by English geologists in referring the fluvio-marine beds of the Isle of Wight and the New Forest to their proper place among the great divisions of the Tertiary strata. Some authors place the whole of these beds in the Eocene, but this can only be done by unnaturally extending upwards the bounds of that division so as to include these Isle of Wight strata. In the paper just read to the Society, Prof. Judd shows that while the several marine Eocene faunas, those namely of the Barton, the Bracklesham, and the Bognor beds, are very closely related to one another, the Brockenhurst fauna has but little in common with them. Thus, out of nearly 200 species of marine shells found in